Headquarters Department of the Army
PB-70-00-1

ARMY RD&A

JANUARY–FEBRUARY 2000

Manufacturing Technology

Corpus Christi Army Depot . . .

ROTARY WING AIRCRAFT SUSTAINMENT

Eldon V. Anderson, Dr. John F. Ayala, T. Elaine Lambert,
Rodney D. Mayo, and Dr. Don T. Phillips

Introduction

Declining budgets have increased DOD's emphasis on producing higher quality products with reduced cycle time at a lower cost. Competition with industry, downsizing, base closures, privatization, changing environmental laws, and the use of current weapon systems beyond their intended life cycle are significantly changing the way depots do business.

The Corpus Christi Army Depot's (CCAD's) Industrial Engineering Department has developed a multiyear applied research, development, test, and evaluation program for rotary-wing aircraft sustainment to reduce operation and maintenance costs. CCAD, which provides remanufacturing and logistics support for all Army and some Navy, Air Force, and Marine Corps helicopter systems, is using manufacturing technology (MANTECH); reliability, maintainability, and sustainability; and the National Defense Center for Environmental Excellence funds to deliver better products, faster and cheaper. CCAD services helicopter blades, engines, transmissions, gearboxes, avionics, hydraulics, and airframes. This article provides an overview of current CCAD projects including expert statistical process control (SPC) for job shop and sustainment operations, computer-matrixed thermal-curing blankets for main rotor blade composite repair, universal static balance stands for main rotor blades, and beneficial stress induction in rotary-wing flight-critical components. (For more information, see *Army RD&A* magazine, September-October 1997, Page 35).

Statistical Process Control

A new expert SPC system developed for the CCAD machine shop operations addresses the unique technical challenge of statistically controlling processes with small unit sample sizes and high-product mix. Both ISO 9000 and parts visibility require data traceability for both part and process data. ISO 9000 refers to a commercial standard established by the International Organization for Standardization that reflects the shift away from military specifications. To analyze data for problem resolution, out-of-control analysis, and variance component identification, both part and process traceability capabilities were implemented. This analysis is facilitated by using data stored in a distributed architecture built around a system-based relational database structure. The system supports both attribute and variable charts, Pareto analysis, and original equipment manufacturer (OEM) specifications superimposed on the standard control limits. Pre-control, short-run, and trend analysis are also supported.

This is the first time that expert SPC has been applied on a distributed online basis throughout all depot sustainment operations. The new applicability in the job shop and sustainment operations sets this effort apart from any other past SPC sustainment effort and offers a choice for other remanufacturers. The project is being distributed to other operations at the depot where repeatable measurement and data logkeeping can be automated to reduce cost.

Main Rotor Composite Repair

Main rotor blades are one of the most critical elements for flight performance, and the composite repair techniques employed by the depot require high levels of precision. Removal of critical leading-edge subassemblies requires rebonding part of the blade, and the heat applied during that process must only cure the damaged repair area while not exceeding the thermal limits of the remaining areas. Controlling temperatures on a length that exceeds 24 feet is no easy task. If the nondamaged area is overheated, then a blade is suspect because the original cured adhesive systems may have been compromised.

To eliminate this potential overheating concern during main rotor composite repair, CCAD developed, demonstrated, and placed into depot remanufacturing production a thermal curing blanket that can maintain a temperature of 250 degrees Fahrenheit, plus or minus 5 degrees, over a 24-foot-long bonding surface. This is a reliable, durable, and repeatable method by which main rotor leading edge de-icing mat sheath assemblies (one of the depot's most difficult advanced composite repairs) could be replaced and rebonded. By using control feedback and closer heat zoning, this effort demonstrates control of localized heating over a long span to plus or minus 5 degrees. This project, completed in December 1998, provides technology that can be horizontally applied to any repair dealing with thermal curing using heat blankets.

Universal Static Balance Stand

CCAD and its contractors, General Research Corp. and AVION, have developed a digital method to static balance several different blade models and types on one fixture at a low cost for both depot and field operations. This replaces currently used large hard tooling for each helicopter model and type in the depot environment. Once implemented, this single flexible fixture will replace 10 existing customized depot fixtures and will enable users to statically balance any type of main rotor blade with one fixture.

Currently, each rotor blade type has its own static balance fixture even though the calculated span-wise center of gravity and adjustment is similar. Some fixtures provide the chord-wise center of gravity and overall blade weight (all other blades are weighed later in the process). A teetering system is used to establish a rough range static balance, leaving movement of tip end weights to operator discretion. Fixture variability causes great variability on the dynamic balancer (whirl tower) later in the process. Greater variability on the whirl tower slows operations and makes proper blade tracking more difficult to achieve.

This prototype static balance fixture will support all DOD main rotor blades and provide tighter blade adjustment tolerances within the existing range on the span-wise center of gravity, chord-wise center of gravity, and overall blade weight. Projected supported blade types include the CH-47D Chinook (fore and aft blades), H-60 Blackhawk and Seahawk, AH-64 Apache, AH-1S Cobra, AH-1W Super Cobra, UH-1 Huey, OH-58D Kiowa Warrior, CH-53E Sea Stallion, CH-46, CH-53D, H-2, and H-3.

The new fixture uses a computer connected to three specifically placed load cells to calculate the span-wise and chord-wise centers of gravity and the overall blade weight. Correlation tests with OEMs are ongoing to establish a relationship between the static and the desired dynamic chord-wise centers of gravity. This fixture was initially developed for the field to reduce depot-level blade overhaul. This development will save thousands of dollars in the field and will help the depot maximize vital production shop floor space.

Critical Component Stress Induction

CCAD receives a variety of unique, geometrically complex flight safety parts that require fatigue life enhancement (shot peening). CCAD has started an initiative to increase productivity, decrease cycle time, and improve consistency in organic peening capabilities. Texas A&M University was contracted to determine "as-is" and "to-be" workload and cost profiles, current practices, resources usage, and capabilities.

CCAD maintains a unique position within the wider spectrum of peening applications. Peening requirements focus on helicopter components and closely resemble a job shop operation. Even within a given "part family," a particular component might require significantly different process scenarios. For example, a particular part may have 20 different peenable surfaces, but actual surface conditions may necessitate treating only 5. This wide variation results in different peening profiles, masking requirements, and process procedures. These characteristics are unique to depot operations and pose formidable problems in a transition from manual, labor-intensive peening to highly automated, computer-controlled operations.

A flexible, highly automated, computer-controlled shot peening center was proposed and designed for CCAD implementation. Capabilities include automated recipe downloading, charging, and tool positioning; automated/semiautomated masking; part orientation; and setup. High-precision robots provide accuracy and flexibility to peen a wide variety of part geometries. This project will consolidate all peening specifications, surface inspection procedures, setup and nozzle parameters, and real-time audio and visual aids in a relational database structure. This database will become the "standards" clearinghouse for all depot maintenance work requirements, OEM, and CCAD specification updates and changes. This system uses intranet-based technology, and information-gathering activities have been reduced by an order of magnitude.

Expert Maintenance System

Two critical sequences in the remanufacture of rotary-wing aircraft are the rotor blade remanufacturing operations and its follow-on dynamic balance (whirl tower). There are "bottleneck" operations on the critical path, so maximum availability is required. CCAD, through a contract with Texas A&M University, has installed a predictive and preventive maintenance expert system (PPMES) that captures live sensor data; logs and transforms analog data into digital forms using new "wavelet theory"; performs diagnostic and predictive tests to project failure potential; schedules maintenance; and organizes data for reliability, availability, and maintainability analysis and the establishment of spares management policies. The system works with existing legacy systems. The data display client is designed for maximum flexibility, compatibility, and expansion using standard intranet Web browser "push" technologies.

PPMES will minimize breakdowns and defects, maximize equipment operation rates, reduce life-cycle costs, extend equipment life, improve troubleshooting, and minimize spare and replacement parts inventory. As a consequence, labor and machine productivity will increase for selected mission-critical equipment. The PPMES automates equipment usage tracking and monitors key sources of deterioration. It gathers data and provides statistical analysis capabilities that categorize, summarize, and analyze equipment status and availability. Warnings are sent to machine operators for at-risk operations.

Conclusion

With base closures, privatization, and declining Defense budgets, affordable sustainment of legacy weapon systems is more important than ever, especially when they are used beyond intended design life. To address this new Army After Next reality, CCAD has implemented a multiyear research, development, test, and evaluation effort to capture technologies for operational cost savings. Our challenge is to address the nontraditional, complex remanufacturing production issues that are the Army's high-cost drivers.

ELDON V. ANDERSON was a Senior Industrial Engineer managing the MANTECH Program at the Corpus Christi Army Depot at the time this article was written. He is now a Branch Chief in the Engineering Resource Management Division at the 98th Area Support Group, Wuerzburg, Germany. He received his B.S.E.E. from the University of Idaho.

DR. JOHN F. AYALA, P.E., was a Senior Industrial Engineer managing the MANTECH Program at the Corpus Christi Army Depot and had just completed a developmental assignment in the then Office of the Assistant Secretary of the Army for Research, Development and Acquisition (now the Office of the Assistant Secretary of the Army for Acquisition, Logistics and Technology) at the time this article was written. He is now a Logistics Management Specialist and the Combat Developer's Representative at the U.S. Army Medical Department Center and School at Fort Sam Houston, TX. He received his doctorate in engineering and his MSIE from Texas A&M University, and his B.S.E.E. from St. Mary's in San Antonio, TX.

T. ELAINE LAMBERT is a Physical Scientist Administrator in the Chemical Material Process Branch at the Corpus Christi Army Depot. She received her BSMET from the New Mexico Institute of Mining and Technology.

RODNEY D. MAYO, P.E., is a Senior Industrial Engineer in the Industrial Engineering Division and is a Project Manager for several MANTECH projects at Corpus Christi Army Depot. He received his BSMET from the University of Texas at El Paso.

DR. DON T. PHILLIPS, P.E., is the Chevron Corp. Professor of Industrial Engineering, the Engineering Program Manager for Life Cycle Engineering Operations Management, and the Director of the Texas Center of Excellence in Manufacturing Systems at Texas A&M University, College Station, TX. He received his Ph.D. in industrial engineering from the University of Arkansas, his MSIE from the University of Arkansas, and his BSIE from Lamar State College of Technology in Beaumont, TX.